



AMERICAN METEOROLOGICAL JOURNAL.

A Monthly Review of Meteorology, Medical Climatology and Geography.

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ANN ARBOR, MICH., U. S. A.:
METEOROLOGICAL JOURNAL COMPANY.
19, 21 and 23 Huron Street.

F. A. BROCKHAUS, Leipzig, Berlin, and Vienna, Agent for German and Austrian States.
Single Copies, 25 cents. Per Annum, \$2.00. In European Countries, \$2.25.

AMERICAN METEOROLOGICAL JOURNAL.

AN ILLUSTRATED MONTHLY

DEVOTED TO SCIENTIFIC METEOROLOGY AND ALLIED
BRANCHES OF STUDY.

THE AMERICAN METEOROLOGICAL JOURNAL CO., Publishers and Proprietors,
Ann Arbor, Michigan.

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PRICE,—IN THE UNITED STATES, - - - \$2.00 per year
“ IN COUNTRIES OF THE POSTAL UNION, - - - 2.25 “ “

Agent for German and Austrian States

F. A. BROCKHAUS, Leipsic, Berlin and Vienna.

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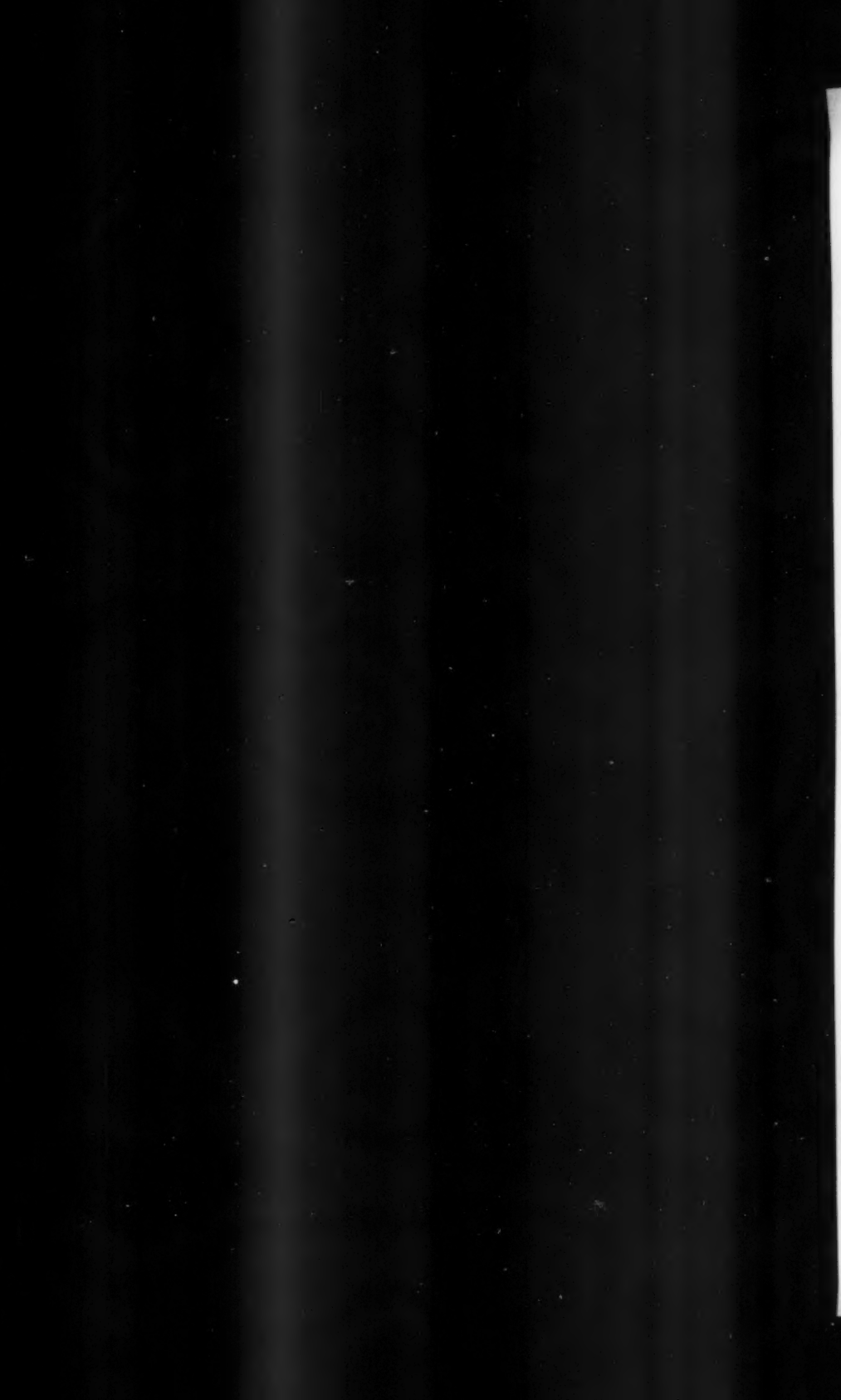
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THE AMERICAN METEOROLOGICAL JOURNAL.

VOL. III.

ANN ARBOR, DECEMBER, 1886.

No. 8.

CURRENT NOTES.

WARM BELT OF WATER OFF CAPE HORN.—The Pilot Chart for November says that Captain Gates, of the ship *L. Schepp*, reports that on April 19, when on a voyage from San Francisco to Liverpool, with a very fresh breeze from S. W., and almost constant violent snow storms, when rounding cape Horn, steering E. by N. (true), the temperature of the water suddenly rose from 42° to 44° . Judging from this that the vessel was too close in-shore he hauled off to E. S. E. (true), and after standing on this course for four hours the temperature fell to 42° . Captain Gates states that on a previous voyage he had noticed this warm belt close in-shore off cape Horn, and judges that it does not extend more than 10 miles off-shore. Captain Gates further says that he would have gone ashore had he stood half an hour longer on an E. by N. (true) course, and only headed off on account of the rise in the temperature of the water. He had not seen the sun for 12 days. The position by dead reckoning at noon was latitude $57^{\circ} 02' S.$, longitude $68^{\circ} 07' W.$

CAPT. W. H. GARDNER.—Just as this bulletin is going to press (Nov. 8th) the news of the death of Capt. W. H. Gardner of Mobile reached the Central Office. It is with a great degree of sadness that we have to record this irreparable loss to this Service. This gentleman was a warm friend and valuable supporter of the State Weather Service and was always ready to give a helping hand to all meteorological interests. He gave many

evidences of extensive study and information concerning the laws controlling the atmospheric changes. He gave to the Alabama Service two valuable papers [Special Papers I. and II.] that will indicate to some degree the extensive knowledge he had of meteorological phenomena. He was a most influential citizen of the State, and his death becomes a public calamity. He was President of the Mobile Cotton Exchange for five years, and in 1883 was elected President of the National Cotton Exchange of America.

Capt. Gardner's influence was frequently exerted, during his life time, in many affairs that tended to the welfare of his native State.—*Bulletin Alabama Weather Service.*

NEW SYSTEM OF WEATHER SIGNALS.—The Chief Signal Officer announces under date of November 10, 1886, that a new system of weather signals will be adopted for general use on March 1, 1887. The new system is based on one designed by Prof. Mell, director of the Alabama Weather Service, and is to be recommended for simplicity, visibility and cheapness. It has four flags; a square white flag for clear or fair weather a square blue flag for rain or snow; a triangular black flag for temperature, hoisted above the white or blue flag for higher temperature, below for lower temperature; and a square white flag with black square centre for the cold wave as at present. When the flags are displayed from a horizontal support, a small streamer will indicate the end from which they are to be read. The absence of red flags will commend these signals for use on the railroad trains, and their moderate cost should aid the extension of their display. Flags of the system now in use should be replaced when worn out by the flags of the new system.

THE CHINOOK RANGE IN BRITISH AMERICA.—The McCloud *Gazette* most emphatically states that the range industry cannot be carried on east of Maple creek in the British territory; and the southern (Montana) stockmen who have selected ranges there will be badly left. The Chinook does not reach that part of the country; the snow lies deep all winter; with the mercury

ranging from 40 to 60° below zero. The *Gazette* was not talking for the benefit of Montana cattlemen, for the purpose of refuting the statements of Lieut. Governor Dewdney, who made a spread eagle speech on the northwest ranges. The fact is that cattle can be wintered with safety in but a limited area of the northwest territories.—*Montana Live-Stock Journal*.

METEOROLOGY AND YELLOW FEVER.—Mr. I. H. Stathem's articles on this subject, which ran through several numbers of Vol. II of this JOURNAL, have been translated into Spanish. They appeared during the spring in several successive numbers of the Mexican *Boletín del Ministerio de Fomento*.

THE MINNESOTA SIGNAL SERVICE is the new title of the former weather service as appears on its October bulletin. The work is now carried on under the auspices of the St. Paul Chamber of Commerce, co-operating with the U. S. Signal Service and the Chicago, Milwaukee and St. Paul, the St. Paul, Minneapolis, and Manitoba, the Chicago, St. Paul, Minneapolis, and Omaha, the Minneapolis and St. Louis, and the Minnesota and Northwestern railway companies. Professor Wm. W. Payne, of Carleton College, Northfield, Minn., is director, and E. C. Brandenburg, U. S. A., assistant. The latter is at the Central Station which is with the Chamber of Commerce at St. Paul. The Chamber appoints a co-operating committee of three, viz., Thos. Cochran, Jr., Wm. F. Phelps, and D. R. Noyes.

This weather service has established a flag service, the object of which is to bring to all important towns and cities of that and adjoining States, the entire benefit of the United States Signal Service daily, from Washington, by use of the telegraph. This is made possible by the generous aid offered by the Chamber of Commerce of St. Paul, the Chief Signal Officer, and the various railroad companies just named.

The Chief Signal Officer at Washington, telegraphs to the central station of the Minnesota service, daily, at midnight, special predictions of weather for the ensuing twenty-four hours, for Minnesota, northern Iowa, eastern Dakota and west Wisconsin.

sin. These indications are telegraphed before eight o'clock, each morning, (except Sunday,) to all the stations on the lines of the railroads before named, for the benefit of the companies and the public generally.

The general officers of these railroad companies have generously consented to give these telegrams to the public free of charge, and their local operators should in no case be asked to deliver these messages as part of their duty. The local operators are rendering the service much assistance, however, by telephoning messages, or otherwise conveying them to place of destination for accommodation of persons in charge of the flags.

During the early part of October there was great irregularity in the telegraph service, chiefly due to the strikes in the cities of Minneapolis and St. Paul. The R. R. companies were greatly embarrassed, and the sending of weather messages became quite impossible. Not knowing these facts, some of the persons in charge of flags became discouraged on account of the late arrival of messages.

All these difficulties are now overcome, and the telegrams of weather indication are sent out with great promptness and regularity. If any failures occur at any station, the Director of the Service requests that prompt notice be given him, for the railway officials have issued special orders in regard to these messages, and they are giving the Service much personal attention.

ROYAL METEOROLOGICAL SOCIETY.—The first meeting of this society for the present session was held on Wednesday evening, the 17th inst., at the Institution of Civil Engineers, 25 Great George street; Mr. W. Ellis, F. R. A. S., President, in the chair.

The following gentlemen were elected fellows, viz.: Mr. B. A. Dobson, Mr. T. Gordon, Mr. H. Mantle, Rev. J. Watson, and Mr. F. Wright.

The papers read were:

(1) "The Gale of October 15th-16th, 1886, over the British Islands," by Mr. C. Harding, F. R. Met. Soc. The storm was of very exceptional strength in the west, southwest, and south of the British Islands, but the principal violence of the wind was

limited to these parts, although the force of a gale was experienced generally over the whole kingdom. By the aid of ships observations the storm has been tracked a long distance out in the Atlantic. It appears to have been formed about 250 miles to the southeast of Newfoundland on the 12th, and was experienced by many ocean steamers on the 13th. When the first indication of approaching bad weather was shown by the barometer and wind at our western outposts, the storm was about 500 miles to the west-southwest of the Irish coast, and was advancing at the rate of nearly 50 miles an hour. The centre of the disturbance struck the coast of Ireland at about 1 A. M. on the 15th, and by 8 A. M. was central over Ireland. The storm traversed the Irish Sea, and turned to the southeast over the western Midlands and the southern counties of England, and its centre remained over the British Isles about 34 hours, having traversed about 500 miles. The storm afterwards crossed the English Channel into France, and subsequently again took a course to the northeastwards, and finally broke up over Holland. In the centre of the storm the barometer fell to 28.5 ins.; but as far as the action of the barometer was concerned, the principal feature of importance was the length of time that the readings remained low. At Geldeston, not far from Lowestoft, the mercury was below 29 ins. for 50 hours, and at Greenwich it was similarly low for 40 hours. The highest recorded hourly velocity of the wind was 78 miles from northwest at Scilly on the morning of the 16th, but on due allowance being made for the squally character of the gale, it is estimated that in the squalls the velocity reached for a minute or so the hourly rate of about 120 miles, which is equivalent to a pressure of about 70 pounds on the square foot. On the mainland the wind attained a velocity of about 60 miles an hour for a considerable time, but without question this velocity would be greatly exceeded in the squalls. In the eastern part of England the velocity scarcely amounted to 30 miles in the hour. The force of the gale was very prolonged. At Scilly the velocity was above 30 miles an hour for 61 hours, and it was above 60 miles for nineteen hours, while at Falmouth it was above 30 miles an hour for 52 hours.

The erratic course of the storm and its slow rate of travel whilst over the British Islands was attributed to the presence of a barrier of high barometer readings over northern Europe, and also to the attraction in a westerly direction owing to the great condensation and heavy rain in the rear of the storm. The rainfall in Ireland, Wales, and the southwest of England was exceptionally heavy. In the neighborhood of Aberystwith the fall on the 15th was 3.83 ins., and at several stations the amount exceeded 2 ins. Serious floods occurred in many parts of the country. A most terrific sea was also experienced on the western coasts, and in the English Channel, and the number of vessels to which casualties occurred on the British coasts during the gale, tell their own tale of its violence. The total number of casualties to sailing vessels and steamships was 158, and among these were five sailing and one steamship abandoned, five sailing and one steamship foundered, and 42 sailing and two steamships stranded. During the gale the life boats of the Royal National Life Boat Institution were launched fourteen times, and were instrumental in saving 36 lives.

(2) "The Climate of Carlisle," by Mr. T. G. Penn, F. R. Met. Soc. This is a discussion of the observations made at the Carlisle Cemetery. The mean temperature for the 23 years (1863-'85) was 47.5° , the absolute highest was 95.0° on July 22nd, 1873, and the lowest -55° on January 16th, 1881. The mean annual rainfall was 29.80 ins.; the greatest monthly fall was 7.84 ins. in July 1884; and the least 0.30 in. in January 1881. The average number of rainy days was 174.

(3) "Results of Hourly Readings derived from a Redier Barograph at Geldeston, Norfolk, during the four years ending February 1886," by Mr. E. T. Dowson, F. R. Met. Soc.

(4) "Results of Observations taken at Delanason, Bua, Fiji, during the five years ending December 31st, 1885, with a summary of results for ten years previous," by Mr. R. L. Holmes, F. R. Met. Soc.

METEOROLOGY AT COSTA RICE, CENTRAL AMERICA.—The following is a summary of meteorological observations taken in

1885, at San Jose, Costa Rica, Central America, by John I. De-Young, Ass't M. T. C. E.

| 1885. | Temperature. | | | | Rain. | | Thu- der | Earthquakes. | |
|----------------|--------------------------------|--------------------------------|---------------------|--------------------|-----------------|-----------------------------------|---------------------------|---|---------------------------------------|
| Month. | Maximum. | Minimum. | Highest daily mean. | Lowest daily mean. | Mean for month. | Number of days on which rain fell | Amount of rain in inches. | Number of days on which thunder occurred. | Days on which occurred and character. |
| | | | | | | | | | |
| January..... | 80 | 58 | 72.0 | 65.0 | 68.33 | 4 | not measured | not taken | Slight on 9th. |
| February..... | 82 ¹ / ₂ | 59 | 74.2 | 64.4 | 70.50 | 1 | | not taken | One slight. |
| March..... | 85 | 57 ¹ / ₂ | 73.8 | 67.1 | 70.66 | 10 | | not taken | " " |
| April..... | 83 | 59 | 74.6 | 69.2 | 72.25 | 10 | | 11 | 23th and 29th. |
| May..... | 84 | 61 | 74.6 | 67.8 | 71.96 | 29 | | 19 | 4th strong, 15th & 16th slight. |
| June..... | 83 | 61 | 75.7 | 66.7 | 72.00 | 24 | | 8 | None. |
| July..... | 80 | 60 | 74.2 | 65.0 | 69.80 | 28 | | 10 | None. |
| August..... | 82 | 62 | 75.6 | 68.2 | 71.60 | 21 | | 11 | None. |
| September..... | 83 | 61 | 74.7 | 68.7 | 70.68 | 25 | 13.15 | 11 | None. |
| October..... | 82 | 59 | 72.2 | 68.7 | 70.57 | 25 | 12.32 | 7 | 11th slight. |
| November..... | 82 | 62 | 72.2 | 68.2 | 70.51 | 25 | 10.42 | 8 | 7th slight. |
| December..... | 80 | 57 | 71.0 | 61.7 | 68.10 | 9 | 1.13 | 2 | None. |
| | 82.2 | 59.7 | 73.7 | 66.7 | 70.58 | 201 | | | |

Communicated by G. A. Hyde, Esq., Cleveland, Ohio.

CERTAIN SMALL OSCILLATIONS OF THE BAROMETER.—The Hon. Ralph Abercromby has studied certain small oscillations of the barometer, not those of squalls and thunder-storms, and his conclusions concerning them are as follows. We take them from the *Quarterly Journal* of the Royal Meteorological Society.

Certain small oscillations in the height of the mercury in the barometer, sometimes called "pumping," have long been known to be associated with gusts of wind, but I do not think that the precise nature of their action has been determined. In this country the oscillations rarely exceed 0.02 inch; and in studying them, I have found the aneroid preferable to the mercurial barometer, owing to the absence of inertia.

The two following examples may be considered typical:

1873, Southend.—Window looking S; wind nearly S, in strong gusts. In this case the first motion of the barometer was always upwards about 0.01 inch, as if the effect of the wind, being arrested by the house, was to compress the air in the room.

1874, Brighton.—A corner house, one window to S, another to W; wind S, strong gusts. With the W. window open there was violent "pumping," but in this case the first motion was always downwards. On opening the S. window as well, the pumping ceased.

The explanation seems to be, that the wind blowing past the W. window drew air out of the room, as blowing through a spray-producer causes suction; but when the S. window was opened, as much air came in as was drawn out, and the pumping ceased.

I believe that all more complicated cases of pumping are modifications of these two examples. I have always remarked that pumping is least marked on the lee side of a house.

It is well known to medical men that many acute diseases, or chronic conditions of exaggerated sensibility of the nervous system, are aggravated by strong wind. Sharp rheumatic pains, breathlessness, and general distress are very common symptoms. Animals indoors are also often uneasy during high wind. In several cases of human beings which have come under my own experience, I have observed the distress to be associated with pumping of the barometer. If we remark that the difference of 0.01 inch of pressure means a difference of 35 grains weight on every square inch, or more than 14 lbs. on the whole human body, and that this change takes place in a very few seconds, it is obvious that "pumping" really involves a very considerable shake to the nervous system.

The above observations, however, suggest a few practical methods of palliation, which may be shortly stated thus: If open windows can be borne, try, by crossing or otherwise altering the drafts, to diminish the distress. When, as in most cases, windows cannot be open, all doors and windows should be closely shut, as well as the vent of the chimney, if there is no fire; and if possible, the patient should be moved to a room on the lee side of the house.

The oscillations due to "pumping" must not be confounded with the small rises and falls which occur in squalls and thunderstorms.

THE DRIFT OF WRECKS gives valuable information concerning the ocean currents in which the wrecks float. Three such drifts, of a remarkable character, are mapped on the November Pilot Chart of the North Atlantic, issued by the Hydrographic Office. One wreck, first seen about 200 miles off Cape Hatteras on February 27, was first driven south, but, getting fairly in the Gulf Stream, it started north about the middle of June. On October 10 it was seen 500 miles south of Cape Race. In four months the current had carried it upwards of 2,500 miles in a northeast direction.

A second wreck, 700 miles east of Hatteras, and consequently beyond the Gulf Stream, made a zigzag southwesterly course of only 750 miles in $7\frac{1}{2}$ months; while a third, first seen in lat. 41° , long. 55° , made a trip down southeast into the center of the Atlantic and back again, appearing after over 7 months in lat. 37° , long. 58° ,—less than 500 miles from its first position.

MICHIGAN WEATHER SERVICE.—Sergeant Conger, of the Signal Office, Lansing, issues a call for observers for a Michigan state weather service. He wishes 250 volunteers throughout the State,—one, at least, to each county. Observers will have to pay for their own instruments, averaging \$15.00 for thermometers and rain-gauge. For further information Sergeant Conger can be addressed directly.

TORNADO STUDIES.—Lieutenant Finley still continues these studies, and the reports are published in the *Monthly Weather Review*, where they are accompanied by charts. The following are excerpts from the August number:

It should be remembered that August is near the close of the tornado season, especially for the states in the Mississippi and Missouri valleys. As determined from the records of a long series of years, June is the month of greatest frequency, August standing sixth on the list, with considerably less than half as many storms.

Considering the tornado season by districts, it may be generally stated that in the south Atlantic and Gulf states they occur

mostly from February 15th to April 15th; west of the Mississippi, from April 15th to June 15; east of the Mississippi, from June 15th to August 15th; in the middle Atlantic states and New England, from July 15th to September 15th.

The tornadoes of August 16th occurred in Wyoming county, New York, between the hours of 3:30 and 4 p. m., local time, as will be seen by reference to the accompanying table.

These storms were associated with low-pressure area number vi., which was central on the afternoon of the 16th just north of Lake Erie, lowest barometer, 29.61, at Toronto, Canada. By reference to the chart, it will be seen that the low-pressure area became extremely elongated to the northeast and southwest, with very high temperatures in the latter portion of the elliptical area. In Indian Territory, Kansas, and Missouri, the temperatures ranged from 95° to 104° . A small area of low pressure, 29.70, formed in northern Missouri, with fresh to brisk winds and high temperature gradients. Over a distance of about three hundred and fifty miles, in a line northwest and southeast, the temperature gradient was 35° , with opposing northerly and southerly winds.

Considering the principal area of low pressure, which was north of Lake Erie, we find the contrast in temperature gradient, with opposing easterly and westerly winds, to be 28° over a distance of about 280 miles in a line due north and south. In both cases the temperature gradient was about 7° per geographical mile. This was the result as determined along the line of maximum gradient in both areas of low pressure, treating them as separate centres of one elongated or trough-like depression. The average temperature gradient for each central area, as determined from four separate measurements, was found to be about $4^{\circ}.5$ per geographical mile in the Missouri depression and about $5^{\circ}.4$ per geographical mile in the Lake Erie depression.

The normal gradient, as determined from the 3 p. m. (eastern time) August temperature charts for several years, is found to be about $1^{\circ}.9$ per geographical mile for the region of the Lake Erie depression, and about $0^{\circ}.94$ per geographical mile for the region of the Missouri depression. From the above it is seen

that the gradient of the former depression was about $3^{\circ}.5$ above the normal, and of the latter about $3^{\circ}.56$ above; this makes the temperature gradient in both regions practically the same, so far as the relation to the normal is concerned; while in the case of the average temperature gradient, the Lake Erie depression was $0^{\circ}.90$ per geographical mile higher than the Missouri depression.

The storm record for the 16th of August was considerably augmented by occurrences in other sections of the country, south and west of New York. From the extreme northwestern portion of West Virginia two heavy cloud-bursts were reported, together with violent winds, causing much destruction to life and property. In northern Indiana violent local storms occurred at, or near, Fountaintown, La Porte, Logansport, and Michigan City. In northern, western, and southern Missouri there were heavy winds and rain; also in northern Illinois, with hail; in northern and central Ohio, and in extreme southern Michigan.

The 16th of August was also the great thunder-storm day of the month, a total of 298 storms being reported from the region embraced by the trough-like depression of low-pressure area vi.

The tornado tracks were located to the southeast of the centre of lowest pressure, in what has been called the "dangerous octant" of an area of barometric minima. In this case the tornado centres were distant about 180 miles to the southeast. The direction of progressive movement of the area of low pressure during the afternoon of the 16th was about east northeast, while the progressive motion of the tornado centres was due northeast, making an angle of about 30° with the former. In the Lake Erie depression the tornado centres lay east of the north and south line of maximum temperature gradients a distance of about 240 miles. In the Missouri depression the local storm-centres lay south and east of the line of maximum temperature gradient a distance of from 260 to 480 miles.

As has been enunciated in professional papers of the Signal Service number xvi., "The Tornado Studies for 1884," there is a definite portion of an area of low pressure within which the conditions for the development of tornadoes is most favorable, and that portion is the southeast quadrant.

CONNECTION BETWEEN METEOROLOGY AND TERRESTRIAL MAGNETISM.

PART II.

In the first communication the more prominent form of terrestrial magnetism, (involving declination, inclination and intensity, as liable to secular changes in the course of some centuries) was discussed briefly; and we are now prepared to examine the

SOLAR DIURNAL VARIATION.

To aid in explaining these phenomena, observed with modifications all over the globe, deflecting the needle in most parts of the northern hemisphere, from greatest easting (beyond the mean daily magnetic meridian) at about 8 A. M., to greatest westing at about 2 P. M., it is necessary to make two experiments:

First, using a thermal pair similar in form to one figured in Ganot's *Physics*, page 753, if we place the apparatus in the magnetic meridian and apply the spirit lamp at the south end, where the two metals are soldered together, (a magnetic needle being pivoted inside on a part of a sewing needle, thrust through a thin section of cork) the north seeking end of the needle will be deflected to the *east*, the same as if an insulated wire passed from the positive pole of a battery, *underneath* the box of a magnetic needle and returned above it. Now let us invert the apparatus and instead of having the Bismuth *below*, as in Ganot's figure, let it be *above*, with the interior magnetic needle resting on the copper, and apply the spirit lamp at the same *south* junction as before, and the north-seeking end of the magnetic needle will be deflected to the *west*, the same as if a wire from the positive pole of a battery passed first *over* the small box compass and returned *underneath* it: showing that the current of electricity in both cases traverses the Bismuth and returns through the copper.

This seems just what we ought to expect: the mode of motion called heat is much more readily conducted by copper * than by

* On the scale of heat conductivity in which Ag. 100, Cu is = 73.6, while Bis. only = 1.8. See Ganot's *Physics*.

Bismuth; being then impeded in the latter as perhaps undulating, radiating heat, it assumes another form of motion, probably more spiral in form: judging from the experiments of Ampère.

It may be well to remark that if we apply ice at the south junction, with the copper uppermost as in Ganot's figure, we reverse the movement of the needle and the north seeking end is deflected to the west; or the same result may be obtained by applying the spirit lamp at the *north* junction of the soldered pair, copper being uppermost.

In order, however to make the above experiment apply to the phenomena of Solar Diurnal observation, in the *northern* hemisphere, we can only use the modification in which heat is applied at the south end (or where, in the compass experiment, the wire passes *over* the magnetic needle) through the less perfect conductor, Bismuth representing our atmosphere, because the equator at the south of the northern hemisphere is much warmer (represented by the spirit lamp) than the arctic regions, and the air is a worse conductor than the earth or the ocean. In the southern hemisphere the phenomena are reversed, the heat passes from the equator, which is at the north, to the antarctic regions at the south: consequently the lamp is applied at the *north* junction of the apparatus, the bismuth representing the atmosphere, being uppermost. Under these conditions, in the experiment meant to indicate the flow of electricity in the northern hemisphere, the north seeking end of the needle is deflected to the *west*, while in the experiment imitating the southern hemisphere and its requirements, the north seeking end of the needle is deflected to the *east*.

In detailing the *second experiment*, the object will be to show that, after we have given to a small box compass, by means of the wooden globe and a battery which we will call No. 1, a certain permanent declination, no matter whether east or west, by placing said box compass in some part of the northern hemisphere, we can afterward *superinduce* on that box compass needle, a slight western deflection, by giving a few turns of a wire emanating from the + pole of battery No. 2, (which may be

of *small* power) winding first *over* the box and returning the wire beneath to the pole of battery No. 2. This imitates the daily deflection to the west, and as soon as the zinc of battery No. 2 is withdrawn, the needle oscillates back to its old position.

In the southern hemisphere, after the needle in the box compass has received its permanent declination, we superinduce a slight deflection of the north seeking end of the needle if we place battery No. 2 opposite the equator and, from its plus pole, coil a few turns of wire over the box and back underneath: because the coil round the box in the northern hemisphere from equator to north pole is left-handed or sinistrorsal, while that from equator to south pole in southern hemisphere, is a right-handed or dextrorsal coil. In both cases we may consider ourselves as located at the equator, the current in the northern hemisphere running from S. E. to N. W.; while in the southern hemisphere, it flows from N. E. to S. W.

It may be proper to call attention to the fact that, in Ganot's figure the arrow indicates the flow of electricity as *first traversing the copper*: a result never obtained in any of the very numerous experiments I have made, judging by the direction of the needle, and comparing its movements with those made by a needle environed by wire, the direction of the current in which can always be determined, by tracing it from the plus pole of the battery.

INFERENCES.

We seem then justified in considering it *probable* that, where the sun's rays strike a given locality, with considerable warmth, about 8 A. M., a portion of that heat, at the junction between the air and the earth or ocean, should be converted into electricity, traversing first the less perfect conductor of heat, the atmosphere, and after flowing toward colder regions, returning either in a lower and colder stratum of air, or in the crust of the earth. It seems also, not improbable that the auroral display in arctic and anarctic regions may be at least partly due to the transference of part of the atmothermal electricity into geothermal electricity: the residue returning in connection with moisture, as clouds surcharged chiefly with positive electricity, to be in

more tropical regions restored to the earth and to equilibrium by terrific thunderstorms.

These atmothermal currents (i. e. air moved by electrical disturbance) may perhaps be supplemented by statical electricity, (generated in vast quantities by oceanic evaporation, tidal and other friction, etc.,) and may perhaps rise 9000 feet or more, to the limit assigned by Piazzzi Smyth, for the upper cloud strata.

Here they may partake to some extent, of the gyratory atmospheric movements, usually sinistrorsal in the northern hemisphere and dextrorsal in the southern. Flammarion remarks: "The aerial routes all incline in the same direction by virtue of a general gyratory deviation." Again after describing the movements in the north he adds: "In the southern hemisphere the normal rotation of aerial currents is exactly the opposite."

THE DOUBLE TYPE OF SOLAR DIURNAL VARIATION.

The north seeking end of the needle, as remarked, is, in the northern hemisphere, deflected slightly each day, usually between 8 A. M. and 2 P. M., from being a little east of the mean magnetic equator in the morning to stand *west* of the same in the afternoon; while in the southern hemisphere the north seeking end of the needle travels *east* during that period. At St. Helena and Singapore, during most of *our* summer, the needle follows the northern type; then comes, at the equinoxes, a period of vacillation, some days the northern type and, on other days, the southern type, until when the sun is fairly vertical over parts of the southern hemisphere, the Solar Diurnal Variation is entirely in accord with the southern type: the north seeking end of the needle being deflected to the *east*.

It does not seem difficult to account for this phenomenon, especially at Singapore, which is, according to the best globes and physical geographies, at the intersection of the January and July isothermals of 80° F.; besides being close to the intersection of the equator of dip and intensity with the terrestrial equator. This would lead us to expect two very similar seasons, one corresponding with the northern summer, the other to the southern, and Singapore would be on the climatic equator.

To some extent these remarks would apply to St. Helena, inas-

much as that Island is almost on the equators of dip and intensity and not far from the isotherms of 80° F. for January and July. But when we find the same phenomenon at the Cape of Good Hope, it is more difficult to apply this argument, although the above isotherms take a great bend south in middle Africa; and the missionary Grout, assures us that during the eight years spent in Caffraria and Zulu Land, he saw roses in bloom every month of the year, and he, as well as Livingston, make frequent mention of double crops and cite warm weather in the winters of that latitude, between Zambesi and Port Natal on the east, as well as in Livingstone's travels from the Makololo Land to Angola on the west. Still, as snow frequently falls at the Cape of Good Hope, it is difficult to account for the double type there, although doubtless, when more astronomical stations are established, we may expect it at such places as the Gallasagos Islands, and in French Guiana, near which the January and July isothermals of 80° F. also intersect.

RICHARD OWEN.

[TO BE CONTINUED.]

LOOMIS' "CONTRIBUTION TO METEOROLOGY."

[CONTINUED.]

CAUSE OF THE PROGRESSIVE MOVEMENT OF STORMS.

In his third and fourth papers Loomis examined hourly observations of rainfall made at Philadelphia, U. S.; at Prague, Austria, and at several stations in Great Britain; and found a decided tendency toward a maximum rainfall in the afternoon, which was especially marked at Philadelphia and Prague. He infers this is true for the whole of the United States and is probably the cause of the diurnal variation in the velocity of storms. He also found a tendency which was especially marked at the British station toward a secondary maximum of rainfall in the morning hours.*

In his 17th paper Loomis forms a composite of the position of

* Dr. Sprung, in *Das Wetter*, May 1886, maintains that there is in Europe an increase in the intensity of storms in the early morning hours.

the centers of the rain-areas in all of the storms during thirty-seven months of the Signal Service observations, by placing the central point of a transparent piece of paper over the center of each storm in succession, and marking the position of the rain areas relative to the storm center. He says :—"We thus learn that for the whole period of 37 months, during great rain storms the principal rain center was most frequently situated nearly in the direction of the average progress of the low centres. The average direction of the storm tracks * * is 15° north of east, which corresponds pretty nearly with the direction in which the principal rain-centres were most frequently found. This co-incidence indicates an intimate connection between the rain fall and the direction of a storm's progress. If, however, we make the comparison for each case separately, we find anomalies which appear to indicate either that the stations of observation are too distant from each other to show satisfactorily the form and position of the rain-areas, or else the direction of the storm's progress is influenced by other circumstances than the amount of rain-fall."—Loomis' 17th paper.

Loomis' earlier researches seem to show an intimate connection between the velocity of storms and the extent of the rain-fall in front of them. In the United States "the average extent of the rain-area on the east side of the storm center is 500 miles. When the rain area extends more than 500 miles on the east, the storm advances with a velocity greater than the mean, but when the extent of the rain area is less than 500 miles the storm advances with a velocity less than the mean."—Loomis' 1st paper.

In his 12th paper Loomis tabulated and examined all those storms in the United States which had been observed to move with unusual rapidity (1,000 or more miles a day) and found that "the area of rain generally extended a great distance in advance of the storm center, the average distance being 667 miles, but there were several cases in which the rain extended but little eastward of the storm center."

One storm occurring Nov. 24, 1873 "moved toward the northeast at the rate of 54 miles per hour, leaving the center of prin-

cipal rain-fall almost exactly in the rear."—Loomis' 7th paper.

Nor can the usual movements in these latter cases be entirely explained by an unusual drifting of the upper air at such times; since the wind velocities on Mount Washington, tabulated by Loomis in his 12th paper for comparison, are not found to be extraordinary. Loomis found in those storms moving very slowly or retreating toward the west in the middle latitude, against the prevailing movement of the atmosphere, that there were in some cases extensive rainfall to the west of the storms, but in other cases their movement could not be referred to the influence of precipitation on the west side.—Loomis' 7th, 14th, and 17th paper.

"These cases of very slow motion, as well as those of very rapid motion, indicate that the direction of movement and rate of progress of a storm center do not depend exclusively upon the amount of rain-fall or upon the distribution of rain-fall within an area of low pressure, but also upon the distribution of pressure, temperature and humidity throughout an extensive region surrounding the low area on all sides. Moreover, the influence of barometric pressure is generally much more obvious than that of temperature, or humidity. An examination of the International weather maps indicates how the progress of a storm center may be influenced by another storm prevailing at a distance of several thousand miles."—Loomis' 17th paper.

In his 14th paper, Loomis "examined all of those cases [between 1873 and 1878] in which the charts of the United States Signal Service indicate the movement of a storm center towards any westerly point." "The number of these cases is 13; and four of these pursued a course about N. N. W.; two advanced towards the N. W.; one towards the S. W.; and three towards the S. S. W." In order to compare these with similar cases on the Atlantic Ocean and in Europe, Loomis also examined Hoffmeyers daily charts from December, 1873, to October, 1876; the charts of the Deutsche Seewarte from January, 1876, to March, 1879, and from January, 1880, to April, 1880; also the charts of the International Observations from November, 1877, to December, 1879. In all of the cases, both in Europe and America, he

found that the pressure was higher to the east than to the west of these storms. In most cases there was a decided area of high pressure to the east, while farther to the east prevailed a storm of considerable magnitude. In many cases there was a second storm immediately to the west of the retreating storm; and in all, there was an area of relatively low pressure. "Thus we see that while on the east side of these low areas there were causes which tended to increase the pressure on that side, there were different conditions on the western side which tended to divert the winds westward, and this is apparently the most important reason why, in these cases, the centers of least pressure advanced westward."

Where there was a second decided barometric depression to the west of the retreating storm, "in several cases the two depressed areas approached each other until they coalesced, by which means the eastern low center was apparently transported westward. * * * In several other cases the two low areas approached each other until they formed a single low area of an elongated form, with two low centers which remained for several days distinct from each other. * * * Thus we see that in Europe and over the Atlantic Ocean, as well as in the United States, the influence of one area of low pressure upon another is a very common cause of abnormal movements of storm centers."

In his twelfth paper, Loomis examined all of those cases found in Europe during 1876-1877 and in the United States from 1872-1877 in which storms moved with the unusual velocity of 1,000 or more miles a day. In seeking the cause of their rapid movement, he says:—"Several of them apparently resulted from the mutual influence of two low areas. * * * In such cases the eastern low area is generally retarded in its progress, and is sometimes turned backward toward the west. At the same time the progress of the western low area must be accelerated."

He further says, these rapid moving storms "were all accompanied with high winds, and some of them with violent winds; they were generally accompanied with a great fall of rain or snow, and the rain area generally extended to a great distance in front of the storm's center; but the most noticeable circum-

stances which characterize all of the cases is the great extent of abnormal winds in front of the storm's center. These abnormal winds were apparently due to an area of high barometer situated on the south, southeast, east, or northeast side of the low center."

The existence of an area of high pressure to the west of a storm is also an important cause of the rapidity of storm movement. In referring to a rapidly moving storm in his 17th paper, Loomis remarks,—“This is one of the numerous cases which appear to indicate that an area of low pressure can not advance rapidly unless an area of high pressure advances behind it.”

In his third paper, Loomis made an especial study of the “influence of a neighboring area of high barometer upon the progress of a storm.” He selected and tabulated all those cases during 1872-74 in which there was a high pressure area to the north of a storm, and then determined the average velocity and direction of the storm progress. He did this in turn for all those cases in which the highest barometer was situated toward each of the eight points of the compass from the storm center, and obtained the following table of results.

| Direction of high barometer. | Number of cases. | Velocity of storm. | Direction of storm path. |
|------------------------------|------------------|--------------------|--------------------------|
| North..... | 23 | 26.0* | N. 58° E. |
| Northeast..... | 39 | 26.4 | 54 |
| East..... | 90 | 25.4 | 83 |
| Southeast..... | 75 | 29.5 | 90 |
| South..... | 25 | 30.3 | 93 |
| Southwest..... | 20 | 26.1 | 81 |
| West..... | 37 | 28.8 | 70 |
| Northwest..... | 19 | 28.7 | 62 |

*The velocities are expressed in miles per hour.

“ * * * * The observations indicate that when the high barometer is on the east side of a storm, the velocity of the storms progress is diminished eight per cent.; and that the velocity is increased by about the same amount when a high barometer is situated on the south side of the storm. The effect of an area of high barometer upon the direction of a storm's progress seems to be more decided, the course of the storm being most northerly when the high barometer is on the north-

east side, and most southerly when the high barometer is on the south or southeast sides * * * *."

[The table shows that the velocities are lowest when the high pressure area is between north and east, or southwest of the storm; and highest when the high pressure is southeast, south, west, or northwest of the storm; and it would seem to follow that the storm progress due to the influence of areas of high pressure would be most rapid when there was at the same time a high pressure both to the west and to the south, or to the northwest and southeast.]

In his 12th paper, Loomis finds two storms, one on Nov. 24, and the other on Dec. 14, 1872, which moved with exceptional rapidity; and yet the rainfall within the storm area was abnormally small. He says,—“The rapid movement * * * was apparently due to their position between two areas of high barometer, one, on the northwest side and the other on the southeast.”

He also thinks that high pressures both on the northwest and northeast side of a storm favor rapid storm progress. In his 17th paper when speaking of two rapidly moving storms he remarks,—“ * * * there was an area of high pressure on the northeast side and another on the northwest side, which condition seems to favor the rapid progress of low centers * * *.” [This last conclusion, however, seems to be based on comparatively few cases.]

In his 12th paper, Loomis takes especial pains to point out that the abnormal movement of storms due to the distribution of pressure is entirely different from a mere drifting of the storm with a mass of air moving in the direction of storm movement. He says, the storm movement is rather “like that of a wave, and its apparent motion results from a subtraction of air from one side and an addition of air to the opposite side. * * *”. The pressure is diminished on the east side of the low area and increased on the west side, in consequence of which the low center suffers a displacement with reference to the earth’s

* A similar influence of areas of high pressure over storm movements has been found in Europe by Ley and Van Bebber.

surface, and the rate of progress of the low center will depend upon the rate at which the pressure is reduced on the east side, and restored on the west side." He illustrates this by the example of a rapidly moving storm in the United States on Jan. 15, 1877. The pressure both on the northwest and northeast sides were quite high, though the pressure on the northwest side was apparently the highest and nearest to the storm center. He says,—"** * ** we can see a reason why the pressure on the west side of the low area should be rapidly restored. The air from the north and northwest rushed in with great velocity. *** *** On the northeast side of the low center the wind was generally from the northeast by which means the air was drawn off from that region and the pressure diminished."

Loomis thus recognizes several causes producing the progressive movement of storms.

1st. In the middle latitudes "the prevalent movement of the winds toward the east. The result, however, is not due to a general drifting of the mass of the atmosphere within which the low area is formed; but to the fact that the pressure on the west side of the low area is more steady and persistent than on the east side."*—Loomis 21st paper.

2d. "The warm and moist air on the east side of the low center rises from the earth's surface and is supplanted by the cold air which presses in upon the west side. The great extension of the rain area on the east side causes an unusually rapid fall of the barometer on that side, and a corresponding advance of the storm's center."—Loomis 12th paper.

*The present writer fails to see the distinction insisted on here. It does not seem that the persistent pressure on the west side of the storm could cause the storm to move more rapidly than the surrounding air; for if it did, the storm would tend to leave a vacuum in its rear, and thus reverse the conditions which are supposed to cause its movement. To say that the storm moves along with the prevailing wind in the same direction, and with the same velocity seems but to say it drifts. Loomis has shown that there are additional causes producing the movement of the storm; but these are movements added to the drifting, just as a body floating in a stream might receive an additional impulse from external forces.

3d. The storm motion is influenced by the "distribution of pressure, temperature and humidity throughout an extensive region surrounding the low area on all sides. Moreover, the influence of barometric pressure is generally much more obvious than that of temperature or humidity."—Loomis 17th paper.

REMARKS BY THE PRESENT WRITER.

As it was previously shown that the several recognized causes of the origin and development of storms might be included under the one law, viz., that: *Storms originate and are maintained by such differences of pressure as tend to make the air move inward toward a central area of minimum pressure*; so the causes of the progressive movement of storms may be expressed by a similar law, viz: *Storms tend to move toward the side on which the forces in action tend to produce a decreased pressure and away from the side on which the forces in action tend to produce an increased pressure*. The many immediate causes which are I think included under this law are as follows:

1st. The general movements of the atmosphere in which a storm is located causes a persistent pressure on the side of the storm from which the atmosphere comes. This tends to increase the pressure on that side; while at the same time the atmospheric movement tends to carry the air away from the opposite side and diminish the pressure on that side. As a consequence the storm moves, or drifts, in the general direction of the atmospheric motion, which in the tropics is toward the west, and in the middle latitudes toward the east.

2d. Ferrel has shown that the centrifugal force developed in storms on account of the earth's rotation is greater on the polar, than on the equatorial side of storms. This greater centrifugal force tends to diminish the pressure on the polar side of the storm center, and in consequence causes a displacement of the storm center toward the pole. This poleward tendency of the storms in all latitudes is one reason why storms do not, as Loomis has shown, always move in exactly the same direction as the general atmospheric motion.

3d. When two storms approach near one another, the air is drawn out from between them, the pressure falls, and the cen-

ters of lowest pressure, or storm centers, are displaced toward the middle area and usually coalesce. In such cases there is not necessarily a bodily movement of the whole of the air composing either storms; but a displacement of the center of lowest pressure, and a forward movement of the storm impulse, which may be more rapid than that of the air in any part of the storm.

4th. When an anticyclone is situated on the edge of a storm, it tends to increase the pressure on that side of the storm on which the usual circulation of the air in anticyclones causes the wind to blow most directly in toward the storm center; and to diminish the pressure on that side of the storm on which the anticyclonic circulation tends to carry the air away from the storm center; and the storm center tends to be displaced from the side on which the pressure is increased toward the side on which the pressure is diminished. When an anticyclone is on the south side of a storm, the anticyclonic circulation tends to increase the pressure on the west side of the storm and decreases the pressure on the east side, and the storm moves then more directly toward the east than usual and with unusual velocity; but when the anticyclone is between north and east of the storm, the air tends to be forced into the east side and carried away from the north side; so that it is readily seen that under such conditions the direction of the storm would be most toward the north and its velocity less than usual. And so in all the cases of the influence of an anticyclone on storm movements found by Loomis, an allied explanation applies. In such cases the storm movement is not entirely due to drift; but rather to a displacement of the center of lowest pressure, and a forward movement of the storm impulse. Thus, suppose for example, what is a common occurrence, that there is an anticyclone to the southeast, and at the same time another to the west or northwest of the storm center. In such cases the anticyclone to the southeast would tend to carry the air away from the east side of the storm and into the south side of the storm, while an anticyclone on the west side would tend to carry the air into the north and west sides and away from the south side. This latter tendency, however, would be counteracted by the influence of the anticy-

clone on the south side; and the resultant of the whole would be a rapid filling up of the pressure on the west side, and a diminution of the pressure on the east side, so that the center of low-pressure might be displaced toward the east more rapidly than the air moving anywhere in its vicinity.*

5th. The distribution of temperature influences the distribution of pressure around a storm. Theoretically, the effect of a high temperature on one side of a storm would seem to be twofold. First, an expansion of the air by heat would cause a bulging up of the air, and thus an increased pressure in the upper air; second, this increased pressure over the region of heat would cause the upper air to move away and the pressure at the earth's surface would decrease in the heated region and increase in the colder regions. Ley, Köppen, and Van Beber find a decided effect of the first kind, viz., that areas of high temperature act in deflecting storm-movements like areas of high pressure, and areas of cold act like areas of low pressure.†

6th. The distribution of humidity tends to change the distribution of pressure around a storm. Air containing a greater aqueous vapor is lighter than air containing a lesser amount; consequently an increase of the aqueous vapor on any side of a storm tends to diminish the pressure on that side, and a decrease of aqueous vapor to increase the pressure. This question has not been very fully investigated, but Sprung claims that his investigations in Europe have shown an unmistakable tendency of storms to move toward the side of greatest relative humidity.‡

7th. Theoretically it would seem that condensation and precipitation of aqueous vapor would tend to produce several effects. First, by an increase of temperature of the air column the upper air would be lifted up and the pressure increased

* I have dwelt on this point because Van Beber has claimed that the movement of storms under these conditions can be explained by saying they drift with the surrounding atmosphere.—*Meteorologische Zeitschrift*, July, 1886, p. 295.

† See Ley's "Laws of the Winds and Storms"; *Meteorologische Zeitschrift*, April, 1886, p. 158; Van Beber's "Handbuch der Ausübenden Witterungskunde," II Theil.

‡ See Sprung's "Lehrbuch der Meteorologie," p. 257.

above; second, as the upper air flowed off the pressure would be diminished below; third, a decrease in aqueous vapor would tend to increase the pressure. Loomis' investigations seem to show that the second effect predominates, for he almost invariably found a diminished pressure with extensive precipitation and a decided tendency of the storm centre to move toward the center of precipitation.

8th. It would seem that the distribution of atmospheric electricity might influence the distribution of pressure. Little or nothing is, however, known of this agent.

The influence of different forces in producing changes in pressure I think needs further investigation; but this will not affect the law given above in regard to the influence of pressure changes on the movement of storms; for this law I believe represents an observed fact, and will not be affected by any changes in the view as regards how that fact is caused.

The two laws which I have italicized above were derived from a study of all of the data available; and are, it seems to me, in our present state of knowledge, the simplest expressions to which the causes of the origin, development and progressive movement of storms can be reduced. These laws are, I think, however, but special examples of the well known physical law that *motion tends to occur along the line of least resistance*. Air tends to move inward toward the point of least pressure because the resistance to motion is least on that side; and storms, which are merely bodies of air in motion, tend to move toward the side of diminished pressure for the same reason.

As a well known result of this law of least resistance, when motion is once set up in any medium, succeeding movements occur most readily along the same line. Ley and Van Bebber have found confirmation of this in the fact that there is frequently a marked tendency of storms to follow one another along the same track, until the series is broken up by some outside influence and a new system inaugurated. As a result, too, of the laws of motion, all motion, especially that in an elastic medium, tends to become rythmical, as shown by numerous familiar examples; and the present writer believes he has found

a tendency to rythm in meteorological changes. Storms frequently follow one another at approximately regular intervals until this is broken up by other influences. These intervals vary at different times from two to many days, though there seems to be a marked tendency to intervals of $3\frac{1}{2}$ and 7 days between storms as experienced at any one place.

H. HELM CLAYTON.

September 14, 1886.

[TO BE CONTINUED.]

AN INVESTIGATION OF CYCLONIC PHENOMENA IN NEW ENGLAND.

(Continued.)

THE CYCLONE OF JANUARY 9TH, 1886.*

The cyclone which traversed New England January 9th, 1886, was a remarkably complete example of those cyclones which move along the eastern states from the Gulf of Mexico. It was not only unusually well-developed and severe, but it crossed that part of New England where the observing stations are most numerous, and where observations of the meteorological conditions are made with especial fulness. The centre passed near the U. S. Signal stations at New York, New London, Boston and Portland, and almost directly over the stations at Providence, Blue Hill and Chestnut Hill and near that at Central Park, N. Y., where self-registering instruments are in constant use. The opportunity was therefore especially favorable for studying the cyclone in minute detail, particularly those characteristics in the line of advance of its centre. The request for detailed observations made during Jan. 8th, 9th, and 10th met with a most generous response, and is here gratefully acknowledged.

This cyclone developed north of Texas on the 6th and moved southeasterly to the Gulf of Mexico; curving to the northeast it re-entered the country on the 7th. On the 8th it moved easterly to Alabama with a pressure at the centre of 29.5 inches; it then

* This section is a revision of a paper read at the meeting of the New England Meteorological Society, April 20, 1886.

curved to the northeast, the pressure falling at its centre to 28.7 inches, and on the 9th moved rapidly over Delaware, Rhode Island, eastern Massachusetts, and western Maine to the St. Lawrence. It diminished in violence and probably was dissipated north of Canada. There were peculiar conditions prevailing at this time over the country east of the Rocky mountains, especially of temperature, to which the unusual development of this cyclone must be referred. On the morning of the 9th, the pressure ranged from 30.8 inches in the northwest to 28.7 inches at the centre of the cyclone in Delaware. The temperature ranged from -50° (50° below zero Fahr.) to 30° at the centre of the cyclone and 60° in southern Florida. An area of excessively cold air was therefore entering the country and pressing southeasterly. This area in its advance over the country was one of the most intense on record, penetrating far into the southern states after the passage of the cyclone. The *Monthly Weather Review* for January, 1886, devotes much space to this cold wave, with chart illustrating its progress on successive days. The U. S. Signal Service printed its tri-daily maps,* in addition to its usually daily map, for five successive days, for the convenience of students. Much assistance has been obtained from these maps in this investigation.

The study of the observations made in New England during the passage of this storm has not been confined to precipitation, but includes all the conditions for which records are available. These will be discussed in order, and some conclusions derived from the results obtained. The following table is given as a sample of the many records available for discussion. It gives only a part of the observations at the stations selected, which are chosen because lying very nearly in the central path of the storm. The minimum pressures given are those obtained at the regular hours of observation and are not necessarily the lowest reached, except at Providence and Blue Hill observatories, where there are self-recording barometers. The maximum tempera-

* It may be well to point out an important misprint in these maps. The third map for each day contains the observations at 10 P. M., not 11 P. M., as stated.

TABLE IX.

Observations at stations near central path of storm, Jan. 8th and 9th, 1866.

| | New Haven. | New London. | Providence. | Blue Hill. | Boston. | Newburyport. | Portland. |
|-------------------------|-------------------|------------------|------------------|--------------|------------------|-----------------|-----------------|
| Pressure, | 9th, 7 a. m. | 28.863 | 28.872 | 28.973 | 28.969 | 29.137 | 29.251 |
| " | " 3 p. m. | 29.043 | 28.901 | 28.713 | 28.728 | 28.773 | 28.808 |
| Temperature, | " minimum | 28.861 | 28.69* | 28.687† | 28.728 | 28.772 | 27.808 |
| " | " 7 a. m. | 11 | 27 | 26 | 26 | 7 | 2 |
| " | " 3 p. m. | 13 | 23 | 24 | 23 | 16 | 16 |
| " | " maximum | 28 | 28 | 30 | 29 | 18 | 20 |
| Wind direction, | " 7 a. m. | N. E. | N. E. | N. E. | N. E. | N. E. | N |
| " | " 3 p. m. | W. | S. W. | S. W. | S. W. | light | N |
| " velocity, | " 7 a. m. | 32 | 26 | 37 | 32 | light | 31 |
| " | " 3 p. m. | 11 | 20 | 36 | 32 | light | 14 |
| " | " maximum | 44 | 29 | 65 | 64 | 53 | 40 |
| Time of maximum | 9th, 5.45 a. m. ‡ | 9th, 3 a. m. | 9th, 5 a. m. | 9th, 5 a. m. | 9th, 4.45 a. m. | 9th, 4.40 a. m. | 9th, 5.25 a. m. |
| Snowfall, melted | 0.64 | 1.47 | 1.90 | 0.45 | 1.10 | 1.82 | 0.24 |
| Snow began | 8th, 11.30 p. m. | 9th, 12.10 a. m. | 8th, 11.30 p. m. | night | 9th, 12.30 a. m. | 9th, 12-1 a. m. | 9th, 3 a. m. |
| Snow ended | 9th, 2 p. m. | 9th, 8.46 p. m. | 9th, 3 p. m. | 9th, 2 p. m. | 9th, 4 p. m. | 9th, 6 p. m. | 9th, 7.25 p. m. |
| Clear first noted | 8th, 11 a. m. | | | 8th, 3 p. m. | 8th, 3 p. m. | 8th, 2 p. m. | 8th, 11 p. m. |

* At 1.45 p. m.

† At 2.40 p. m.

‡ Also a second maximum of 40 miles between 1 and 1.30 p. m.

tures and wind velocities are in all cases from self-recording instruments. The extreme violence of the wind is of especial note.

The characteristics of this storm will now be pointed out, as indicated by the several meteorological elements.

(1) *Pressure*.—The lowest pressures recorded were 28.69 inches, as given in the above table. This extreme value was noted at Philadelphia, Providence and Blue Hill, and has rarely been recorded in New England. After the storm entered the state of Maine, the pressure rose slowly at the centre. The accompanying map, chart vi, contains the path of the centre of the cyclone across New England, carefully

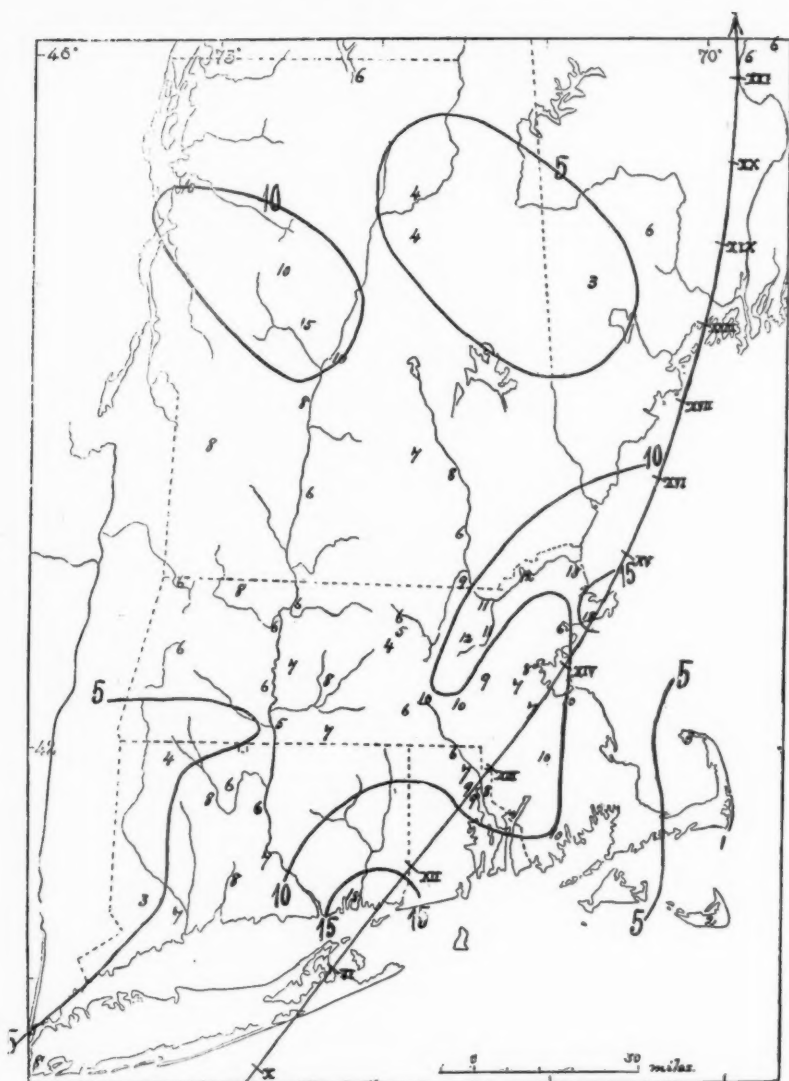


CHART VI. *Part of cyclone, January 9, 1886, with estimated snowfall.*

The Roman numerals indicate the hours at which the cyclone centre occupied its successive position. The snowfall is estimated in inches, and the lines of equal snowfall drawn at intervals of 5 inches.

drawn from the observations of pressure. The hours, indicated by Roman numerals, are in the standard time of the 75th meridian and are numbered continuously up to 24, the afternoon hours being designated by those between 12 and 24.

Besides the extreme lowness of the pressure, the fluctuations of the values from hour to hour are of especial value. In order to illustrate the barometric movements, the following chart is given, chart vii, which contains the records of the self-registering barometers at Blue Hill, Providence and Central Park, New York. At all of these stations Draper's self-recording pencil barometer is in use. The published curves are tracings from the original records furnished by the observers themselves. The Blue Hill tracing is given without alteration, but the horizontal scale of the Providence record has been doubled, to accord with that of the former station, the vertical scales being identical. For a similar reason the vertical scale of the Central Park record has been increased by one-half, the horizontal scale agreeing with that at Blue Hill. With these changes, made necessary for publication in a common scale, the curves are given as made by the respective instruments. The minute fluctuations are represented only approximately. The curves are for an interval of twenty-four hours at each station, and the hours are as follows, so selected that the lowest points of the curves may lie approximately in the same vertical line.

New York, 7 P. M., 8th; 7 P. M., 9th.

Providence, 11 P. M., 8th; 11 P. M., 9th.

Blue Hill, 12 P. M., 8th; 12 P. M., 9th.

The corrections to these curves to reduce to sea-level are respectively: New York, +0.11; Providence, +0.07; Blue Hill, +0.68 inch.

The barometric curves show that the fall of pressure was not uniform but much more rapid about eleven hours before the lowest point was reached than at other times; they also show to a marked degree the peculiar fluctuations, which are usually recorded whenever a well-developed cyclone is passing, the cause of which is not yet clearly understood. These fluctuations are most marked in the Blue Hill record. The rise of the pressure

after the centre had passed was slower and more uniform than the fall preceding its passage.

(2) *Temperature.*—The temperatures as noted at the many stations in New England were near or below freezing at the beginning of the storm, followed by a rapid fall after its passage, as the intense cold wave from the west immediately followed. There are two Richard thermographs, one at Chestnut Hill, Mass., the other at Providence, whose records have been available for discussion, and also a Draper thermograph at Central Park, New York. As these curves show very peculiar fluctuations, they are here reproduced, chart viii. The curves at Chestnut Hill and Providence are given in the exact scale of the original record. The scale of the Draper thermograph is very much greater than that of the others; it has therefore been reduced in copying to the former scale. The scale as printed is exactly that of the original record at the two former stations.

An examination of these curves shows that the records at Chestnut Hill and Providence substantially agree. They indicate that the usual diurnal fall of temperature in the night was checked at about midnight, Jan. 8th, and in its place a rise of temperature of about 7° took place, which reached its maximum just before sunrise on the 9th. This was followed by a fall of 15° and a similar rise a few hours later, the second maximum agreeing approximately with the first. After this maximum, which occurred near the usual time of the daily maximum (2 or 3 p. m.), the temperature rapidly fell. The New York curve shows an agreement with the other records in some respects, but is dissimilar in others, as may be seen by comparing them carefully. The question arises, to what extent these fluctuations are due to the cyclone and to what to the usual diurnal fluctuation, as modified by the cloud conditions of the sky. It is clearly impossible to decide this question with certainty, but its answer may be attempted by noting the points of agreement and disagreement in the curves and the attendant conditions. The storm-centre passed New York, Providence and Chestnut Hill at about 9:30 A. M., 1 and 2 P. M. respectively. It passed about fifty miles southeast of New York and nearly over the other sta-

tions. At all of the stations it was snowing from about midnight of the 8th until 3 or 4 P. M. of the 9th, so that the cloud conditions were similar. We notice that the three curves agree in the checking of the diurnal fall of temperature on the evening of the 8th, and in a rapid rise, which occurred at New York about 4 P. M., and at the other stations near midnight. Each shows the same general condition for six hours following—temperature nearly stationary with a slight fall and subsequent rise. Each shows the fall of 10° to 15° immediately succeeding, but

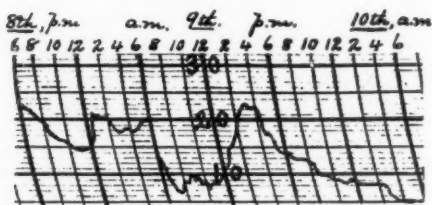
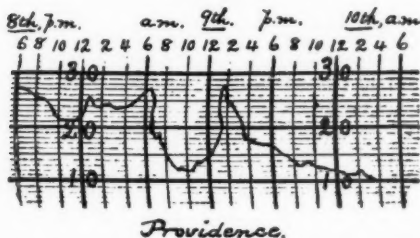
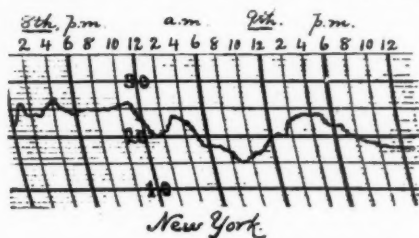


CHART VIII. Thermometric curves at New York, Providence and Chestnut Hill.

Vertical scale is temperature in degrees Fahrenheit; horizontal scale is time in intervals of two hours.

at New York the fall was more gradual and the later rise also more gradual, so that the second maximum of the 9th occurred at New York even later than at the other stations. The curves therefore disagree in the length of time between the two maxima, which is thirteen hours at New York, seven hours at Providence and nine hours at Chestnut Hill. The minimum point at New York occurred at about the time that the storm-centre was nearest, while at the other stations the second maximum had been reached at its passage. In interpreting this comparison, it may be considered that the first named points of agreement are due to the advancing cyclone. The records at New York precede those at the other stations by eight hours; the storm-centre at midnight was moving with an hour velocity of about twenty miles, much slower than when it traversed New England on the following morning. The difference in time corresponds quite well with the rate of the cyclone. We may then infer that the checking of the diurnal fall of temperature, the subsequent rise of about 5° , the approximately stationary condition for six hours, and the sudden fall of temperature were due to the cyclone, and occurred when the centre was distant about 600, 500, 500-250, and 250 miles respectively. The rise of temperature on the morning of the 9th may also be due to the cyclone, but the records do not permit us to locate it at any definite relation to the centre of the cyclone. The rapid fall on the evening of the 9th indicates the advance of the cold wave which immediately succeeded the passage of the cyclone.

(3) *Wind*.—The wind velocities were high as the storm approached, were light when the centre was nearest, and increased again after its passage. The second maximum was not equal to the first at the majority of stations. The following table contains the maximum velocities (in miles per hour) as the storm approached, at those stations furnishing the data. There is also given the corresponding direction of the wind, the time at which the maximum velocity occurred, and the distance and direction of the storm-centre at that moment. The distance in "hours" denotes the interval of time which elapsed before the centre reached its nearest point to the respective stations. The times are in each case on the 9th inst.

TABLE X.

Maximum wind velocities before the passage of the storm center, January 9, 1886.

| Stations. | Max. Vel. | Direction. | Time. | Distance of Centre. | |
|-------------------|-----------|------------|-------------|---------------------|--------|
| | | | | Miles. | Hours. |
| New York..... | 44 | N. E. | 4:40 a. m. | 140 | 5 |
| New Haven..... | 44 | N. E. | | | |
| New London..... | 32 | N. E. | 5:45 a. m. | 240 | 6 |
| Providence..... | 29 | N. E. | 3:00 a. m. | 360 | 10 |
| Provincetown..... | 68* | N. E. | 1:00 a. m. | 470 | 13 |
| Blue Hill..... | 65 | N. E. | 5:00 a. m. | 340 | 9 |
| Boston..... | 64 | N. E. | 4:45 a. m. | 360 | 9 |
| Brattleboro..... | 28 | N. W. | | | |
| Newburyport..... | 53 | N. E. | 4:40 a. m. | 380 | 10 |
| Nashua..... | 29 | N. E. | | | |
| Portland..... | 40 | N. E. | 5:25 a. m. | 380 | 12 |
| St. John..... | 21 | N. E. | 10:00 a. m. | 480 | 13 |
| Average..... | | | | 350 | 10 |

* Estimated.

The records of the direction of the wind at Blue Hill and Boston show great fluctuations which were not so marked at New York, Providence and Newburyport. At the latter stations the wind changed with some fluctuations from northeast through the north to northwest. At Boston, the wind "boxed the compass" several times near noon of the 9th. At Blue Hill, the continuous record gives some very interesting results, which are of especial value from the situation of this observatory on the summit of an isolated hill, 650 feet above the sea-level. At 8:50 A. M., the wind, which had been blowing from the northeast, backed to the west and blew from the northwest and north until 12:15 P. M., with velocity diminishing from 30 to 8 miles per hour. At this time it became variable, blowing from all points of the compass, and settling to a southeast wind which gradually veered to the southwest by 3 P. M., the velocity increasing to its second maximum, 48 miles, at 4 P. M. These changes are interesting when compared with the corresponding barometric record. The point of lowest pressure was reached at about 2:40 P. M. Consequently, six hours before this, the wind changed abruptly and for three hours and a half blew from the northwest and north; then occurred the chief fluctuation when the centre of low pressure was still distant about 75 miles, and for two hours the wind blew not towards but *away* from the point of lowest pressure. As the centre passed directly overhead at Blue Hill, these records show the peculiarities of the wind movements in the path of the storm.

The continuous record at Central Park, New York, is at a station fifty miles from the centre and shows an absence of these peculiarities. At this station, the wind blew steadily from the northeast, (with two fluctuations at 12:10 A. M. and 5:30 A. M.) until 10 A. M., after the centre of lowest pressure had passed its nearest point, when it backed gradually through the north to the northwest and reached the west at 3 P. M.

(4) *Precipitation.*—The precipitation was in the form of snow, and as the wind blew violently, its amount at the several stations cannot be given with accuracy. It has seemed best to use the observers' estimates of the depth of snowfall instead of the records of melted snow, in examining the distribution of the snowfall, and the map, chart vi, is accordingly so drawn. As far as can be determined from such imperfect data, the maximum area lies in the path of the storm, as in the case of other cyclones which approach New England from the south.

As the snow was packed solidly by the wind, the amount of water obtained by melting a section of average depth was much larger than is usual. At Chestnut Hill and Providence one inch of snow yielded 0.21 inch of water, and the average of seventeen stations, where the determinations were carefully made, is 0.15 inch.

The snow began to fall at the several stations in the night or early morning, when the storm-centre was at an average distance of about 470 miles; it ceased falling when the centre had passed beyond the several stations to a distance averaging fifty miles. The duration of the snowfall was about fourteen hours, of which twelve and one-half were before and one and one-half after the passage of the storm-centre.

(5) *Cloud movements.*—The first cirri which heralded the advancing storm were noted at the several stations in the afternoon of the 8th. In Table IX are given the times at the stations mentioned. The average of the times at all the stations for which the data are available, which are situated nearly in the line of advance of the storm center, shows that the cirri began to gather about twenty-four hours before the arrival of the center, when its distance was about 950 miles, or about twelve hours before the snow began to fall.

Several observers made especial note of the partial breaking away of the clouds near the time of the passage of the center, followed by their gathering again. The observer at Newburyport remarks: "The sky was entirely overcast on the morning of the 9th until about 11 o'clock when the clouds broke sufficiently to enable me to see plainly that they [upper clouds] were moving from S. S. E., although the wind was N. N. E. Several times from 11 A. M. to 3 P. M., I observed the clouds again moving from S. E. or S. From 3 to 4 P. M., the clouds seemed to hang very low and were exceedingly black and heavy in N. E. and S. E., while they frequently broke away near the zenith and to the W. and S. W. of it, disclosing blue sky. (Snow was falling all the while in small quantity.) At this time (3 to 4 P. M.,) the motion of the clouds was from S. S. W., moving rather fast. As far as I could see, there appeared to be no upper clouds at that time." It should be noted that the storm center, (which has been taken in this paper as coincident with lowest barometric pressure) passed near Newburyport at about 2:50 P. M. The partial clearing above described, therefore preceded the passage of the centre.

The observations at the basis of the above description, have been further studied to see if they would throw any light upon the difficult subject of the mechanism of a cyclone. The special stations in New England are so situated as to give the conditions in the line of the storms advance, while the stations of the U. S. Signal Service outside of New England give the conditions at definite points on the western side. The conditions on the east cannot be given because the track passed so close to the coast line. An attempt was made to combine all the observations at the different stations upon a single chart in order to obtain a "composite" of this cyclone. The method consists of moving a piece of tracing paper from place to place, so that its centre shall fall successively upon the cyclone centre at the different times of observation. At each position, the observations at the several stations are located on the chart. In this way the successive records at any given station appear on the chart in their proper relation to the centre of the cyclone at the various times, and a combination chart is obtained which includes all the ob-

servations. The assumption of the method is that the cyclone retains a definite character from hour to hour to such an extent that the observations can be safely combined, though made several hours apart. Unfortunately there is abundant evidence that the assumption is false in the case of this cyclone, and the method was reluctantly abandoned. The barometric records have been carefully tabulated for the observations 8th, 10 P. M.; 9th, 7 A. M., 3 P. M., and 10 P. M.; (the three hours of the U. S. Signal Service telegraphic observations,) supplemented by observations in New England, and the evidence is conclusive that during the transit of the storm over New England it was undergoing rapid changes, at least in the conditions indicated by the barometric readings. The pressure was rising slowly at the centre but was relatively lower at stations removed from the centre, as the storm moved along. There was greater change on the left of the path of advance than on either preceding or following sides.

The storm was at its greatest intensity as it entered New England; the following chart, Chart IX, is therefore given to illustrate the observed conditions at this time. It is derived from all the observations available relating to pressure, temperature, wind direction and velocity. The individual observations of pressure and temperature are omitted in printing, but the full lines are the isobars or lines of equal pressure drawn at intervals of 0.1 inch, the dotted lines the isotherms or lines of equal temperature drawn at 10° intervals. The stations of observation are especially abundant on the upper part of the chart, preceding the centre. The observations of the wind are given at each station reporting them, as they are relatively fewer. The arrows indicate the direction, flying with the wind, and the adjacent numbers give the velocity in miles per hour. The centre of the cyclone at the time of observation was near Philadelphia. The corresponding charts for other others might be given, but the number of observations on which they depend is not so great as at 7 A. M. They show the changes in the conditions commented on above, which indicate that the storm had begun to decrease in violence.

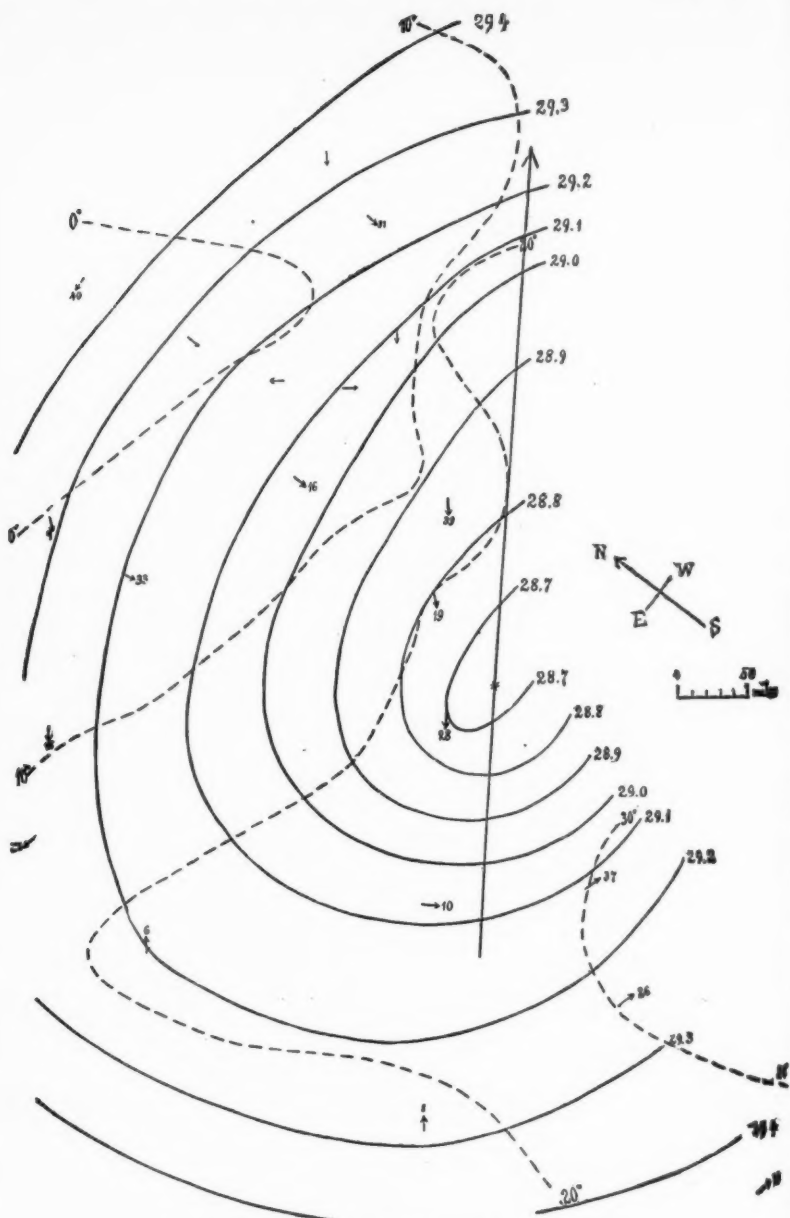


CHART IX. Map of storm January 9, 1886, at 7 a. m.

Full lines are isobars, dotted lines isotherms, arrows fly with the wind, figures adjacent to arrows denote wind velocities. The long arrow shows the direction in which the cyclone was moving.

The chart illustrates the severity of the storm at the time of observation. The closeness of the isobars is especially to be noted, the gradient in the steepest part being 0.1 inch for 22 miles. The crowding of the isolars 29.1 and 29.0 on the forward side of the centre is probably real, as it depends upon a number of reliable observations. The isotherms show the rise of temperature at the centre of the cyclone; they also indicate the approach of the intense cold wave from the north. The wind arrows show, with one or two exceptions, the direction required by theory about a central depression. The velocities are hardly comparable as they are made at the several stations under varying conditions of exposure.

The theory of the mechanism of a cyclone, which is at present received with the most favor, is in brief that at the centre of lowest pressure there is an ascending current of relatively warm, moist air. This current is fed by the surface winds, which blow from all directions towards the centre in a spiral direction, deviating from a direct line in a direction contrary to that of the motion of clock hands. The upper winds blow outward from this ascending column, curving in a direction the same as that of clock hands, and form at a great distance from the centre an annulus of relatively high pressure. Such a simple structure probably does not exist in a well-developed cyclone, though the theory may be true as a general outline. It has been known for some time that the real structure of a cyclone is far more complicated, and a clearer knowledge of it must be derived from the special study of such cyclones as the one under discussion. The detailed statement of the observations given above has already indicated several important facts which ought to be regarded in studies of this sort. In recapitulation, there may be mentioned as of chief importance the barometric fluctuations. The curves given in Chart VII show not only minor fluctuations, but also several distinct waves of rising and falling pressure, occurring in the course of the general fall of pressure. The three curves agree in four of these, which occur on the Blue Hill curve at 3-4, 5-7, 8-9:30 and 10-12 A. M., the second of them being the best marked.

These deflections may indicate minor ascending or descending currents, as some have thought, or they may be due to other causes; but they must be taken into account in any complete statement of the cyclonic structure. The absence of similar fluctuations on the following side of the cyclone is a second characteristic worthy of mention. That the preceding part of the cyclone is especially complicated is also indicated by the peculiarities in the temperature curves and in the wind records both of direction and velocity. The former have been carefully examined above, and it has been shown probable that they indicate real fluctuations in the cyclone itself. The latter have also been described in detail; the chief peculiarities noted were that the highest velocities occurred when the storm centre was distant about 350 miles, or ten hours before its arrival, and that the change of wind direction occurred several hours before the arrival of the centre. The clearing away of the clouds, also, which is sometimes regarded as coincident with the passage of the centre of lowest pressure, occurred several hours before the arrival of the latter. This storm therefore furnishes evidence of the complicated structure of cyclones. It would be possible to conjecture how these peculiarities may be accounted for, or at least to suggest such modifications in the structure as would include them, but it is not a part of the designs of this paper to enter the field of speculation.

There is one important need in meteorological observations which the discussion of this storm emphasizes, viz., that of an increased number of stations where continuous records of the several elements are made by self-registering instruments. Nearly all the peculiarities specified above were brought into view by the continuous records made at a very few stations, and would not have been discovered from observations at stated times even were the number of stations very numerous. Their further elucidation might have been possible had there been more stations furnishing similar records. It would be a great advantage for future researches if a number of stations with self-registering apparatus could be well distributed over the area visited by cyclones.

BALL, OR GLOBE, LIGHTNING.

On the 19th August last, during a severe thunderstorm, the lightning struck a frame house in New Harmony, exhibiting during part of its course, as far as I can judge after careful examination,* the rare case of ball-lightning. A portion of this lightning passing from the storm-cloud to the earth struck the south east corner of the building about ten feet above the ground and loosened three or four of the weatherboarding. A part then knocked a hole, two feet wide horizontally by six inches vertically, in the lath and plaster of the south wall, and rose from this to the stair landing (at a turn going to the second story) around the east cornice of the room, and thence disappeared. Another portion broke a hole about 8x10 inches in the east plastering of said landing, at $4\frac{1}{2}$ feet above this landing, which is reached from the room by four steps. The family were mostly assembled in this room, and a young lady of intelligence, about fifteen years of age, informs me she saw the ball of fire about the size of a man's head, roll down these four steps and along the carpet without scorching it, out at the east door, a distance of seven feet. In its passage it grazed the foot of the second oldest daughter, and the family physician informed me the great toe was considerably inflamed as if burned; the mother and youngest son were blinded and almost suffocated for several minutes.

Outside, a post in the east fence, about seventeen feet from the door out of which the ball rolled, was reduced from ten inches square to three or four inches in diameter. A tree, about a foot in diameter, fourteen feet from said east door was slightly barked on the west side and had remarkable bruises considerably higher up, about two or three inches in diameter. A somewhat smaller tree, nine feet due south from the first, was entirely stripped of its bark on the northeast side, for seven feet from the ground, leaving countless slivers hanging from that extremity three feet down.

* Being ill at the time with malarial fever, I could not immediately examine the premises and obtain the facts, but I did so a few days later, before any changes whatever had been made in the way of repairs.

Judging from all the evidence, it seems probable that the following may explain in some measure the phenomena observed: The storm cloud approaching from a southwest direction as positive electricity, to meet the negative electricity of the earth, at the east fence post, gave off a portion of its force to the south east corner of the house. These facts I infer from the great explosive force at the fence post and adjoining trees, and the comparatively small damage done inside the house.

Only a few cases are recorded of ball lightning, such as one by Flammarion, in his "Atmosphere," p. 440, at Salagnac, France, where a globe of fire descended the chimney of a house, rolled across the kitchen floor, out to a pig pen, where it killed the occupant, without setting fire to the straw on which it lay. In another case, mentioned in Brocklesby's "Meteorology," which occurred 1809 in David Sutton's house at Newcastle-on-Tyne, the lightning descended the chimney, and several persons saw a globe of fire advance into the middle of the room and then explode.

I venture a suggestive explanation of the *possible* cause in these cases, of this modified form of electricity, while I admit that it would not seem to apply to those cases, where the ball is seen on the water. When coming down the soot of the chimney or through the dust of the crumbled plastering, might not a portion of the electricity be so enveloped in a non-conducting medium as to render its motion more slow and its power for injury less until that envelope is partially removed by striking against a good conductor? The suggestion is based on the idea that the ball would be somewhat in the condition of electricity surrounded by non-conducting glass, as in the Leyden Jar, not exploding until connection is made between the interior electricity and a good conductor outside.

RICHARD OWEN.

NEW HARMONY, IND., 4 Sept. 1886.

A CORRECTION.—Professor Ferrel writes that, in so far as our notice of his resignation from the Signal Service (p. 247) indicates that it was not entirely voluntary, it is incorrect. He had contemplated the change for a year and a half, as soon as certain work on hand had been completed.

THE SONNBLICK OBSERVATORY, THE HIGHEST METEOROLOGICAL STATION IN EUROPE.

This station, which was mentioned by the writer in his account of the "Mountain Meteorological Stations of Europe," *JOURNAL*, vol. II., No. 11, p. 504) as about to be established on the Sonnblick, was opened September 2 of this year. The following facts regarding this notable station are taken from recent numbers of the German meteorological journals: The Sonnblick lies in the Austrian province of Salzburg, in a mining region, the Ranniser mines there being the highest in Europe. It was through the coöperation of Herr Rojacher, the proprietor of these mines, that the German-Austrian Alpine Club and the Austrian Meteorological Society, with contributions from other sources, succeeded in carrying out the plan of building an observatory on the isolated summit of the Sonnblick, 3,100 metres (10,170 feet) above the sea, and of thus establishing the highest permanent station in Europe.

The observatory, which stands upon the edge of a precipice, consists of a storm tower about forty feet high with walls six feet thick at the base, on which it is intended to place an anemometer and wind vane. Adjoining is a one story wooden house, about 40x20 feet, containing three rooms. Besides the ordinary barometer, thermometers and hair hygrometer, there is a self-recording barometer, thermometer and hygrometer, a Campbell-Stokes sunshine recorder and a black bulb solar radiation thermometer. The thermometers are exposed in a lower shelter on the first floor of the tower, on the north side. Difficulty is anticipated in keeping the thermometer sheltered free from ice and the driving snow, which already, on the 17th of September, had clogged it. Dr. Hann remarks that the station on Pike's Peak has a different climate with much drier air and less precipitation to contend with than has the Sonnblick. The writer would observe that no solution of the difficulty has been made at the station on Mount Washington. No method has yet been decided upon by which the precipitation can be measured. The one observer has been instructed how best to maintain the observa-

tions. The observatory is connected by a telephone line on poles with Ranris, and works well over that long distance. From there observations may be telegraphed to Vienna and used in the daily weather bulletins issued by the European Meteorological services. A room is reserved for scientists who wish to pursue investigations at this high station, and as it is under the supervision of Dr. J. Hann, the eminent director of the Austrian Meteorological Bureau, we shall look for interesting results from it.

The top of the tower is of copper and a cable extends from it down the glacier to protect the observatory from lightning. Though the lightning flashes are not bright and the thunder is not loud at this elevation, yet the lightning strokes are sufficient to kill a person and the conductor buzzes continually during a thunderstorm.

A. LAWRENCE ROTCH.

CORRESPONDENCE.

MR. SHERMAN'S WEATHER MOVEMENTS.

TO THE EDITOR:—I have just read in the *Journal* for November, 1884, the article of Mr. Sherman on "Weather Areas and Their Movements," in which he says: "The observations here set forth clearly indicate that there is frequently, if not continuously, a steady and comparatively slow advance of weather areas from west to east, in the latitude of Michigan at least, if not further north and south."

The gradual advance of such a weather area was well marked here at the close of the long drouth from which we suffered during the summer just passed. Our position (Sumner county) is on the southern boundary of the state and about the middle of the state east and west. Accurate reports reached us of abundant rainfall in the western counties three or four weeks before any rain fell here. This area of rainfall gradually advanced eastward. So slow was its progress, that teamsters who reported abundant rains only forty or fifty miles west of fully a week previous to any rainfall here. Correspondence with parties in the eastern part of the state enables me to be measurably certain that this same progressive movement continued eastward across the state.

I am sorry I am not able to give a report of more thorough and accurate observations; but perhaps the facts, such as they are, may not prove entirely uninteresting.

Very truly yours,

J. M. LATTA.

MILLERTON, KANSAS, Dec. 8, 1886.

THUNDER-STORMS MOVING FROM EAST.

TO THE EDITOR:—In reply to your inquiry in the October JOURNAL, p. 247–8, whether thunder-storms are ever found moving from the east in this country, I would say that thunder-storms moving from some easterly direction are not very uncommon in Tennessee. In fact, I think some such storms occur almost every year. I observed four during one month, viz.: June 1884, at Murfreesboro, Tenn. On June 12th, one was observed moving from E. N. E.; and on June 14th, three distinct storms were observed which came from S. E. These storms moved in exactly the same direction as the upper currents had been moving during the day, as shown by the movements of detached cirrus clouds. I find from the U. S. Weather Review that these thunder-storms occurred in the rear of a nearly stationary general storm which was located just east of Tennessee.

The reason why such storms do not occur in high northern latitudes is, I think, due to the fact that the conditions are not favorable to the development of thunder-storms when the movements of the upper clouds are from some easterly point as they sometimes are, for I have observed such movements both in Michigan and Massachusetts.

Such movements of the upper currents have been observed only on the north side of storms, and I think such a position is never favorable for the development of thunder-storms except in southern latitudes in summer when the vertical decrease of temperature is nearly always large.

H. HELM CLAYTON.

HAIDINGER'S BRUSHES.

TO THE EDITOR:—Will you kindly explain the appearance of a violet and yellow Roman cross that may be seen upon white clouds when the sun is shining brightly? The colors are not always in the same position, i. e., the violet may be perpendicular and the yellow horizontal or vice-versa. The same phenomenon may be observed if one looks through a Nicol at a white paper placed in the direct sunlight. The colors in that case are more intense.

Very respectfully,

S. M. L.

November 23, 1886.

[The phenomenon in question is called Haidinger's brushes from the discoverer who first called attention to it a score or more years ago. With a Nicol they can be seen by about one person in two,—always by dark-eyed persons. They are rarely seen with the naked eye, as described by F. M. L., on clouds. A still smaller class of persons can see them on a clear sky about 90° from the sun. Haidinger's brushes are

undoubtedly phenomena of polarized light, and belong to the eye of the observer. Their explanation, however, is apparently not yet complete.—ED.]

MR. BISHOP'S ESSAY.

TO THE EDITOR:—I have read with very great interest Rev. Sereno Bishop's articles respecting "The Origin of the Red Glows," in the July and August numbers of your METEOROLOGICAL JOURNAL, and I write to ask your permission to reprint them, in extenso, in the second edition of my work on "The Climate of Uckfield Sussex," which I am about to publish.

As yet, nothing has been published in England at all approaching to these interesting articles. We have been promised, for a long time past, an elaborate report of these phenomena by a committee of the Royal Society convened for the purpose, but, alas, we wait in vain.

I beg to remain, yours respectfully,

C. LEESON PRINCE.

THE OBSERVATORY, CROMBOROUGH, SUSSEX, England, Sept. 24, 1886.

[We take the liberty of printing this private letter without having obtained the consent of the writer.—ED.]

METEOR OF SEPTEMBER 6, 1886.—The records of this meteor gathered by the Society's observers were submitted to Prof. H. A. Newton of Yale College, from whom the following statement is received: The meteor had an altitude of about 90 miles when first visible, over lat. $44^{\circ} 15'$, long. $73^{\circ} 8'$; and an altitude of 25 miles when it disappeared over lat. $43^{\circ} 20'$, long. 71° . One of its explosions occurred near the centre of this path, the other nearer the end. The meteor was going away from the sun, having had a perihelion distance of about three-quarters of the earth's-orbit radius. The altitudes of 78 meteors observed on Nov. 13-14, 1863, were calculated by Prof. Newton as follows: Mean altitude at first appearance, 96.2 miles; at disappearance, 60.8 miles; at middle path, 78.5 miles. Twenty-nine of these meteors became visible at greater height than 100 miles, and seven disappeared before descending to an altitude of 100 miles. For 39 meteors observed on Aug. 10-11, 1863, the corresponding mean altitudes are 69.9, 56.0, and 62.9 miles.—*N. E. Met. Soc. Bulletin.*





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